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Title: Remote Sensing of Dynamic Events

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Remote Sensing of Dynamic Events

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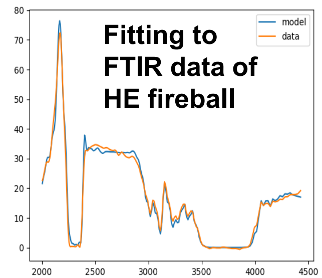
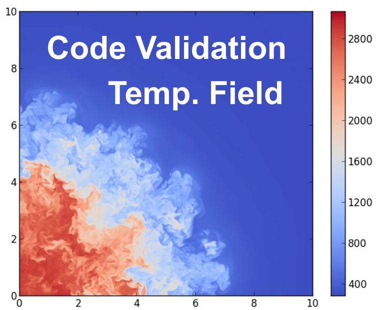
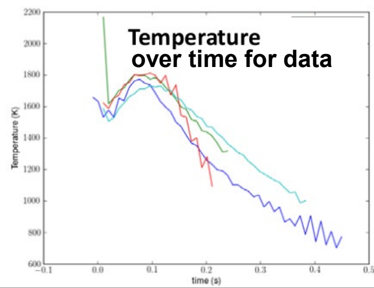
Remote Sensing: Physics Informed Machine Learning







Background Information

Research into using advanced methods for remote sensing applications. A particular interest is in remote sensing of dynamic events involving high explosives (HE) and estimating parameters (e.g., temperature) that characterize the fireball. However, the research is interested in machine learning (ML) for infrared remote sensing in general. The motivation is to improve remote sensing methods of dynamic events to help with validation of computational physics codes.

Research Categories

Research Type:

- [X] Computational
- [ ] Experimental

Research Timeframe:

- [X] Summer Internship
- [X] Academic Year Project

Research Level:

- [ ] Undergraduate
- [X] Graduate

Classification:

- [X] Unclassified
- [X] Classified

Research Focus Areas

Develop white-box or physics informed machine learning (ML) for a remote sensing application involving high explosives.

Compare developed methods with traditional optimization, statistical approaches, and other ML methods.

Additional Background Information

The work mentioned on the previous slide has significant overlap with work by Dr. Kevin Gross who is currently the Director of Center for Technical Studies and Research at AFIT. Dr. Kevin Gross is also an AFIT graduate (Ph.D., 2007). The overlap with Dr. Gross' work is in remote sensing in the infrared and the analysis of high explosive (HE) events with FTIR (Fourier Transform Infrared) sensors. His Ph.D. dissertation consisted of full spectral modeling of FTIR experimental data of HE events in order to extract the fireball parameters (temperature, size, soot absorption coefficient, and gas concentrations for H2O, CO2, and CO). One motivation for his work was to investigate if different types of HEs could be discriminated by using FTIR experimental data. Being able to discriminate between different types of HEs could provide information on who or how the explosive was made (e.g., homemade device vs military grade).

The work on the previous slide is similar in that one goal is to analyze HE fireballs with remote sensors monitoring in the infrared; including FTIR. One of the differences between the work of Dr. Gross and the work on the previous slide is that the proposed work will investigate machine learning (ML) methods to address the fireball parameter estimation problem. Also, the objective of the proposed work is more concerned with advanced methodologies for these type of remote sensing problems and not necessarily on a single application (HE events and FTIR sensors). Another difference is that the proposed work is ultimately concerned with validation of computational codes. This means that the work could also involve evaluating the consistency between computational physics codes and extracted fireball parameters from experimental data and using that information to improve the physics codes.

Additional Background Information

Derek Armstrong has worked at LANL for 14 years in the areas of remote sensing, physics validation, and, most recently, in electromagnetic pulse calculations. For more than 10 of these 14 years, Derek worked half-time on a remote sensing project that developed algorithms and computational codes to detect gases and solid materials with remote sensors monitoring in the infrared. Derek's educational background is in operations research, mathematics, and computer science.

For the past six years, Eddy Timmermans has been developing a molecular opacity capability with a group of collaborators in multiple divisions (XCP,T,AOT-AE). A distinct challenge in reviving this capability for the laboratory is combining the high resolution spectroscopy focus of remote sensing with the low resolution need for radiative transfer calculations. The development of high and medium resolution applications and the analysis of spectral data have provided a motivation for developing the methods and have provided a test bed of the molecular opacity capability. Eddy's background is in atomic physics and condensed matter theory. He was an Oppenheimer postdoctoral fellow, has been at the laboratory for nearly twenty-one years and has been a fellow of the American Physical Society (APS) since 2006.